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ORIGINAL ARTICLE

Mizzia zagarthica sp. nov., a Late Berriasian–Early Valanginian dasycladalean alga from the Fahliyan Formation in the Zagros fold-thrust belt, SW Iran. Re-assessment on the genus *Mizzia*

Seyedabolfazl Hosseini · Marc A. Conrad · Nicolaos Carras · Pascal Kindler

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Abstract Early Cretaceous shallow carbonate deposits in the Zagros fold-thrust belt, SW Iran, are being studied for a high-resolution stratigraphic pattern and detailed environmental analysis. These carbonates contain diversified assemblages of dasycladalean algae, indicating shallow subtidal depositional environments. A new dasycladalean alga and interesting marker is described as *Mizzia zagarthica* sp. nov. from Late Berriasian–Early Valanginian deposits of the Fahliyan Formation. Focusing on the presence of reproductive organs (cysts) in the laterals, the genus, which so far has been reported only from the Permian, is emended. Based on newly described material from Greece and New Mexico, the genus *Mizzia* is re-assessed. The paper also includes a critical revision of the genera *Neomizzia* and *Banciloporella*.

Keywords *Mizzia* · Dasycladalean alga · Berriasian · Valanginian · Zagros fold-thrust belt · Iran

S. Hosseini (✉) · P. Kindler
Section of Earth and Environmental Sciences, University of Geneva, 1205 Geneva, Switzerland
e-mail: seyedabolfazl.hosseini@unige.ch; s_hosseini@niocexp.ir

S. Hosseini
Exploration Directorate, National Iranian Oil Company (NIOC), 1st Dead End, Sheikh Bahai' Sq., Seoul Ave., PO Box 19395-6669, Tehran, Iran

M. A. Conrad
71 Chemin de Planta, 1223 Cologny, Switzerland

N. Carras
I.G.M.E., Spirou Loui 1, Olympic Village, 13677 Achermes, Greece

Introduction

Several articles have been written on the Fahliyan Formation, on the field of general biostratigraphy, sedimentology, tectonic as well as geological setting during the previous decades (Falcon 1961; James and Wynd 1965; Wynd 1965; Stöcklin 1968; Kheradpir 1975; Setudehnia 1978; Berberian and King 1981). None of these articles discuss directly the dasycladalean algae and their application for stratigraphy, except Gollestaneh (1965, 1974, 1979). In addition, some dasycladalean algae have been reported from the Lower Cretaceous strata of the Zagros Basin by Parvaneh Nejad Shirazi (2008). The mentioned authors reported the algal contents of the Khami Group (including Surmeh, Hith, Fahliyan, Gadvan and Dariyan Formations) in the southwestern part of the Zagros Basin, but never precisely delineated the Berriasian, Valanginian, and Hauterivian boundaries. Since 2008, the algal contents of the Fahliyan and Gadvan Formations were discussed in some detail by Hosseini and Conrad (2008, 2009) and Hosseini et al. (2010, 2011, 2013) with an emphasis on their significance for both environmental interpretation and stratigraphic boundaries of the Berriasian, Valanginian, and Hauterivian. The current investigations focus mostly on ten outcrops across the basin, namely Lar, Anneh, Fahliyan, Kuzeh Kuh, Dasht-e Gul, Khartang, Surmeh, Kalagh, Nakh, and Burkh (Fig. 1) that are being studied for both biostratigraphy and facies interpretations. New for the regional record, several algal species were identified, some of them having relatively short stratigraphic ranges and/or being useful paleoecological indicators. *Mizzia zagarthica* sp. nov. is quite common in the middle part of the Fahliyan Formation and mostly appears in areas where the Fahliyan platform shows evidence of a shelf margin to back reef setting. The significance of other important algal

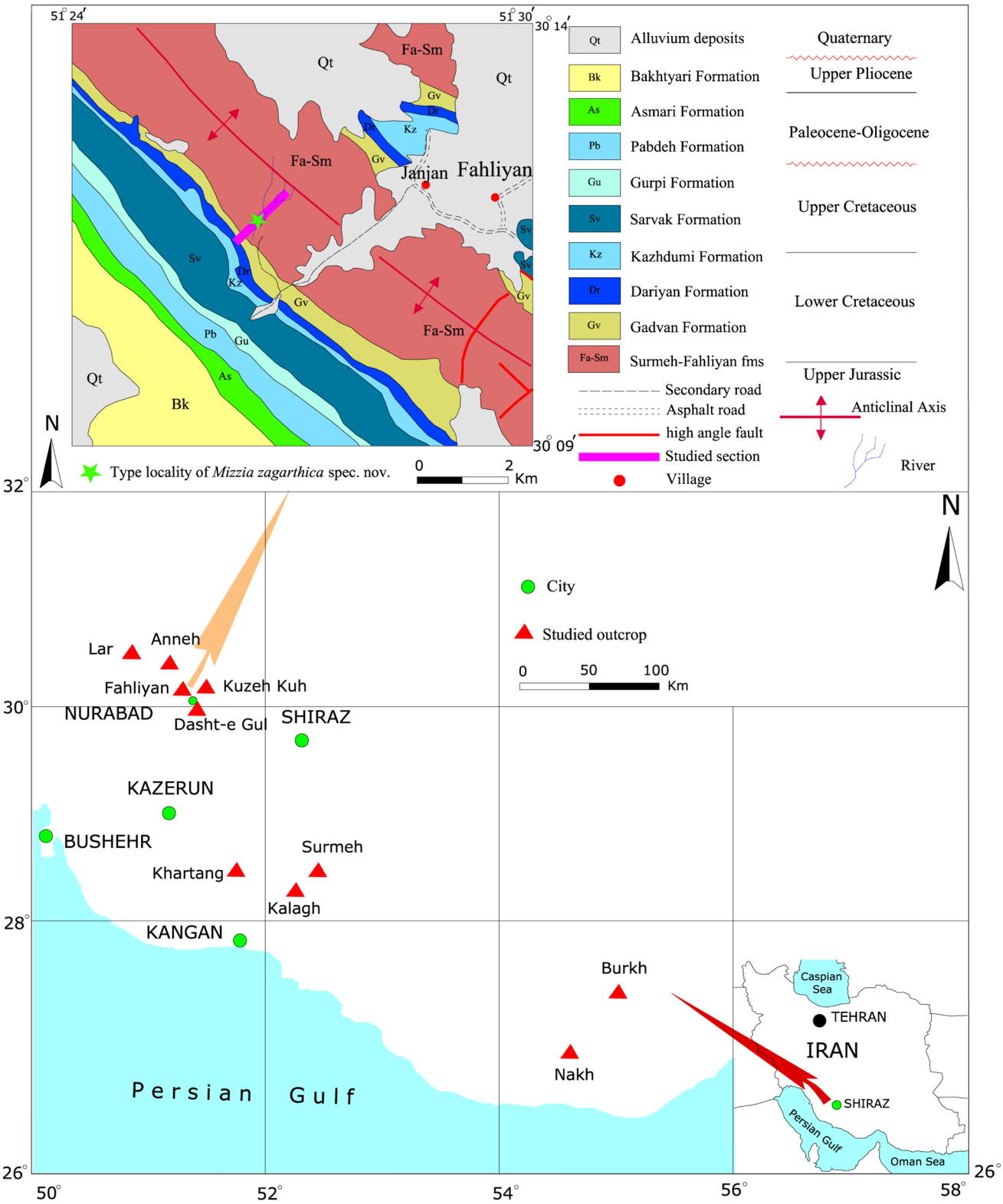

Fig. 1 Location map of the studied outcrops in the Zagros fold-thrust belt and type locality of *Mizzia zagarthica* sp. nov. (*green asterisk*), modified from the geological map of Fahliyan, drawing no. 25482W (1974)

assemblages in terms of high-resolution sequence and biostratigraphy will be addressed in separate articles.

Micropaleontological setting

The Fahliyan Formation in the Zagros FTB includes a diversified assemblage of benthic foraminifera and dasycladalean algae. The following dasycladalean algae were identified so far in this unit that comprises Berriasian to Barremian deposits: *Actinoporella jaffrezoi, A. podolica, Clypeina dragastani, C. estevezii, C. parasolkani, C. solkani, Iranella inopinata*, *Otternstella lemmensis, O. sugdeni*, *Pseudoclypeina crnogorica, Salpingoporella annulata, S. biokovensis, S. cemi, S. circassa, S. hasi, S. hispanica, S. istriana, S. katzeri, S. parapiriniae, S.* aff. *piriniae, S. piriniae, S. polygonalis, S. pygmaea,* and *Selliporella neocomiensis.*

Mizzia zagarthica sp. nov., is described from medium- to thick-bedded limestones of the Fahliyan Formation (Fig. 2a–c). In all outcrops investigated so far (Fig. 1), the FO takes place at levels assigned to the Late Berriasian, environmentally in an internal platform setting.

Systematic paleontology

Phylum Chlorophyta
Class Dasycladophyceae Hoek et al. (1995)
Order Dasycladales Pascher (1931)
Family Triploporellaceae (Pia 1920), emend. Granier and Bucur in Granier et al. (2013)

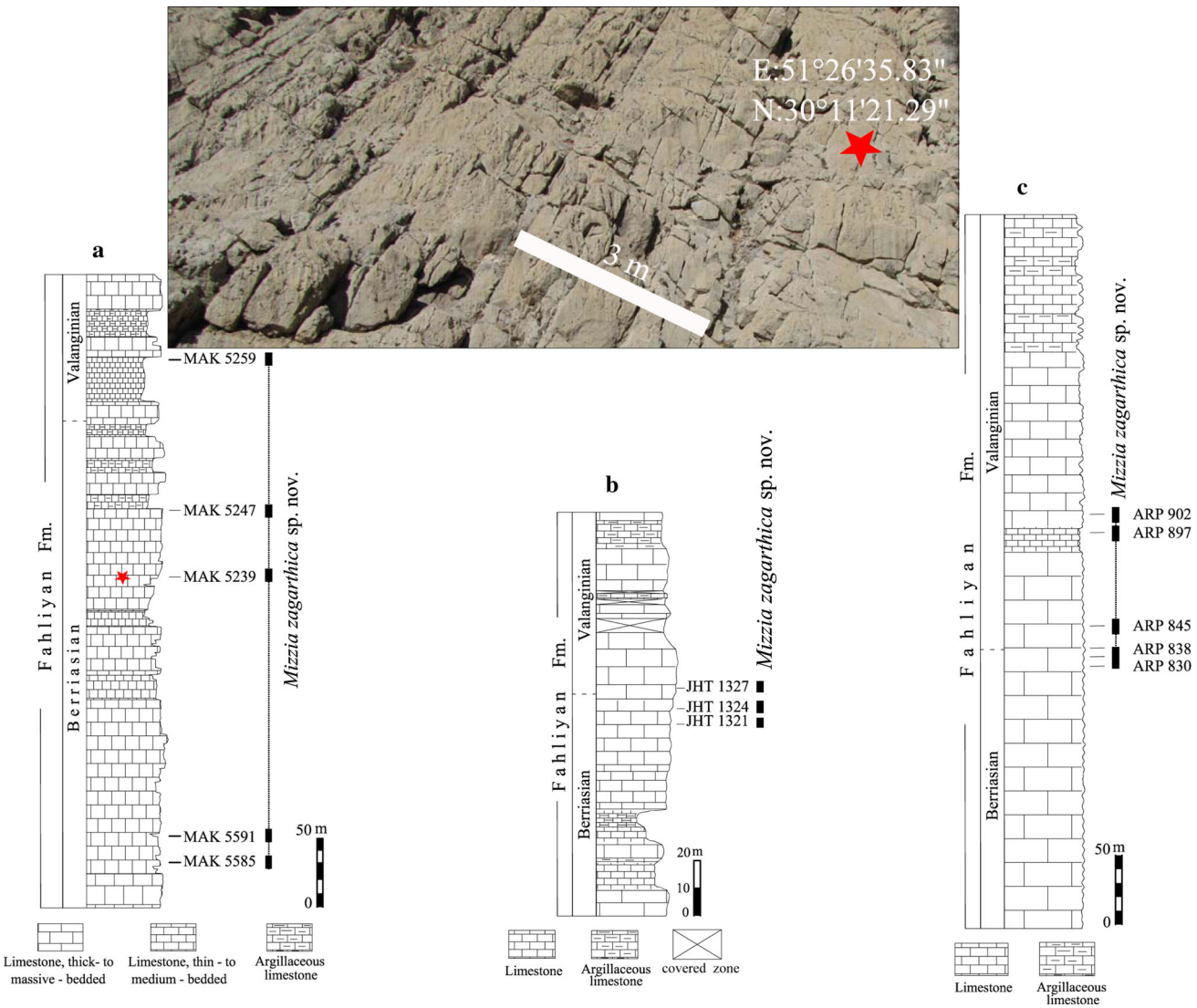

Fig. 2 Lithostratigraphic succession of the Fahliyan Formation in the Zagros fold-thrust belt and location of studied samples. **a** Fahliyan outcrop and type level of *Mizzia zagarthica* sp. nov. (*red asterisk*) within medium- to thick-bedded limestones. **b** Surmeh outcrop. **c** Lar outcrop

?Tribe Triploporelleae Pia 1920, pending revision
Subtribe Mizziinae Bassoullet et al. (1978)
Genus *Mizzia* Schubert (1907), emend
Synonymous genera: *Eogoniolina* Endo (1953)
?*Neomizzia* Lévy 1966
Range: Early Permian to Early Cretaceous
Genotype: *Mizzia velebitana* Schubert (1907)

Remarks Mizzia was established based on numerous specimens of *M. velebitana*, collected from a Permian limestone in the Velebit Mountains, Croatia. Enhanced descriptions and occasionally differing revisions were then carried out by a number of authors including R. Schubert, A. Karpinsky, P. Negris, J. Pia, M. Gordon, J.H. Johnson, Y. Ozawa and R. Rezak, along with the introduction of several other species. For historical reviews including a list of species, geographic distribution, comparisons, and discussions, the reader is referred to the comprehensive articles of Johnson and Dorr (1942), Rezak (1959), Vachard (1980), and Granier and Grgasović (2000). Three steps are examined below, inserting between brackets the modern, customary terms used in this paper.

The essential generic characters of *Mizzia* according to Pia (1920) are cited by Johnson and Dorr (1942 p. 68, 69) as follows: "Dasycladaceae with tallus composed of several members [articles] joined together […] pores [laterals] unbranched, increasing in size toward the exterior. The spores [cysts, reproductive organs] were most probably produced in the stalkcell [main axis of the plant]." Other important characters (ibid., p. 69) call for "the genus *Mizzia* […] the calcareous test varies from a thin layer covering all the internal organs (the stalkcell as well as the proximal part of the verticillae) to a layer thick enough to extend toward the interior as far as the stalkcell." In addition (ibid.), "Pia concluded that the thallus was unbranched [forming a simple necklace], basing this conclusion on the fact that he observed no specimen with two openings on one side." Moreover (ibid.) "in contrast to both Schubert and Karpinsky, Pia believed that the pores might be either open or closed at the outer surface." At that time (1942), *Mizzia* was therefore considered to be endosporate and, because of an erroneous interpretation and incorrect reconstruction made by Pia (1920), implicitly aspondyle (non-verticillated).

An important development was imparted by Rezak (1959) with reference to verticillation. Citing Karpinsky (1908), this author (p. 535) reminded that "Examination of topotype material of *M. velebitana* from Yugoslavia and *M. japonica* substantiates this regular arrangement of the rays [laterals]." Consequently, *M. velebitana* is quite schematically reconstructed suppress (see below) in conjunction with the following generic diagnosis: "the thallus is composed of segments [articles] joined end to end in a loosely articulated fashion. The segments are generally

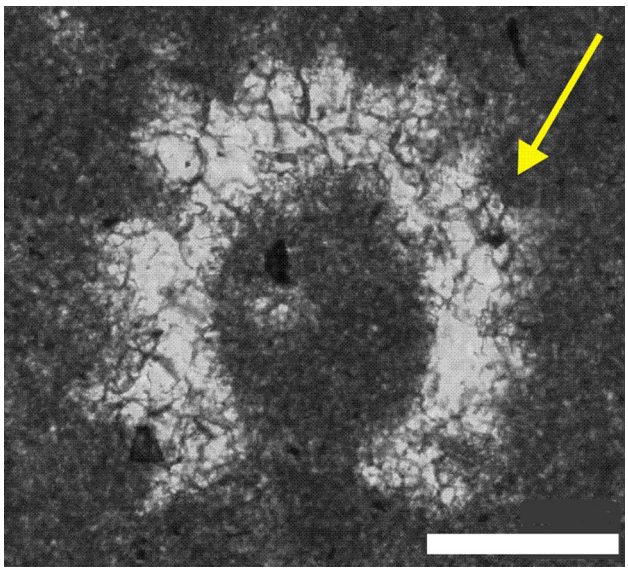

Fig. 3 The holotype of *Mizzia zagarthica* sp. nov. Oblique-transversal section of a single, disjointed article (segment). The lower part of the section illustrates the non-calcified, lower, or upper part of the article. Rather ill-defined (but see also Figs. 5, 6, 7, 8, 9, 10, 11 pro parte), curved imprints of cysts are present in the calcareous skeleton coating the laterals (*arrow*). Sample MAK 5239, Fahliyan outcrop, Zagros FTB. *Scale bar* 100 μm

disaggregated and are rarely found joined together like a string of beads. Individual segments are composed of a central cavity (generally barrel-shaped) through which the stipe extended. Radiating from the central cavity are simple expanding, unbranched rays arranged in regular, alternating horizontal rows. At the periphery of the segment the expanded rays are in mutual contact. The alternating nature of the rays and their crowding at the periphery gives rise to hexagonal (honeycomb) pattern on the surface of each segment […]. Species are based upon shapes and dimensions of the segments and their internal structures." Location of the cysts (reproductive organs) is not addressed by Rezak (1959), however. At that time, *Mizzia* although demonstratively euspondyl (verticillated) is still, implicitly considered endosporate (reproductive organs located in the main axis of the plant).

At last the present paper calls for the irregular, although clear-cut presence of imprints of reproductive organs (cysts) in the skeleton coating the laterals of *Mizzia zargarthica*, n. sp. Also new for the record, similar imprints are found in some specimens of *Mizzia velebitana*, the Permian type species of the genus. Definitely, most of the numerous specimens of *M. velebitana* and other species of *Mizzia* illustrated in the literature do not show this important character, which we nonetheless assign to the circumscription of the genus. An analogous situation is found in certain species of the Mesozoic genus *Salpingoporella* Pia (see Carras et al. 2006) and *Triploporella*

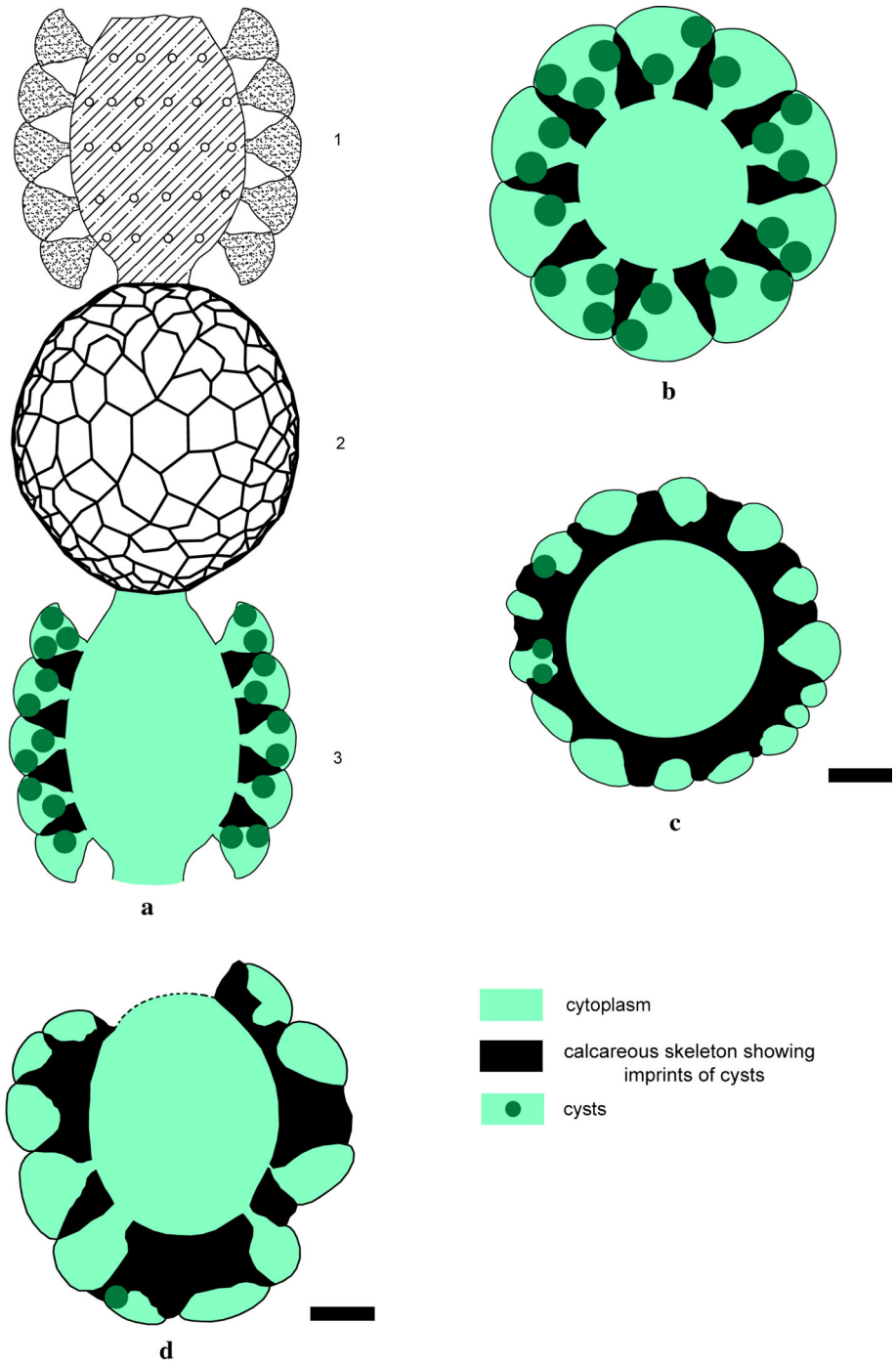

Fig. 4 *Mizzia zagarthica* sp. nov. **a** Schematic reconstruction of a sequence of three articles; *1* outer view, removing the skeleton and frontal laterals; *2* tentative outer view, showing the cortex; *3* axial section. **b** Ideal transversal section. **c** Interpretation of transversal section shown in Fig. 6d. **d** Interpretation of oblique section shown in Fig. 11c. *Scale bars* 100 μm

Steinmann. Also in the latter genus, as emended by Barattolo (1981), reproductive organs formed by cyst-containers, whether subject to calcification or not, are placed in the primary laterals. Consequently a new, second emended generic diagnosis follows.

Emended diagnosis of Mizzia Thallus perannulated (moniliform), made of a string of barrel-like articles (segments), more or less elongated and calcified. Main axis (stalk) of the articles barrel-like, standing contiguous saucer-shaped whorls of laterals. Laterals typically inclined perpendicular to the curved surface of the axis, phloiophorous, not further ramified, distally forming a faceted cortex. Laterals cladosporate, acting as gametophores.

Comparisons Compared to the previous emendation of Rezak (1959, see above), essential changes relate to the shape of the main axis, barrel-shaped instead of implicitly cylindrical, and the presence of cysts (gametangia) in the laterals. In the Dasycladales, concepts ruling the definition of a genus

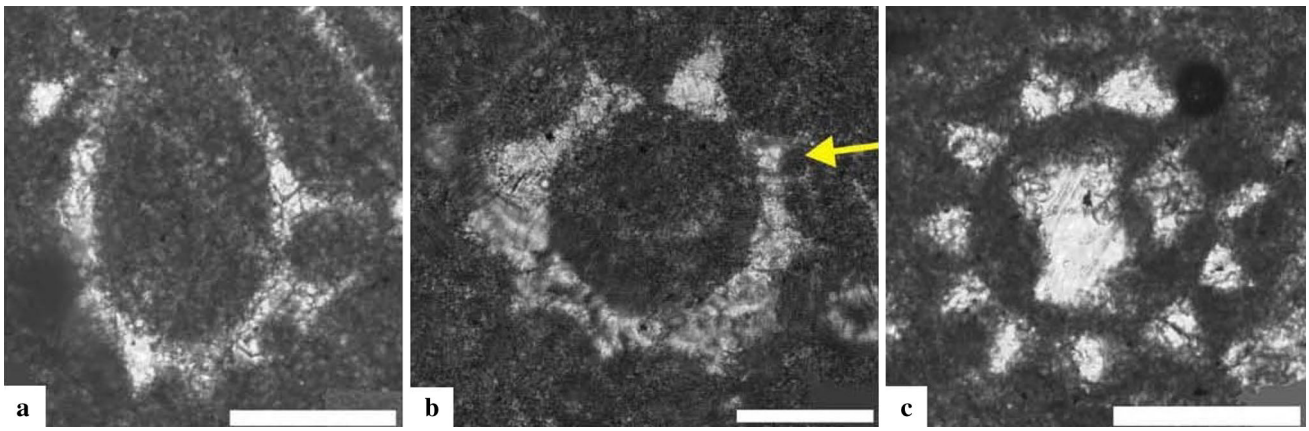

Fig. 5 *Mizzia zagarthica* sp. nov., Dasht-e Gul outcrop, Zagros FTB. Rounded imprints of cysts are present in the skeleton coating some of the laterals (*arrow*). **a** Atypical, oblique-longitudinal section; sample MAK 5649. **b** Almost transversal section showing the clear-cut proximal lumen of the laterals; sample MAK 5662. **c** Transversal section illustrating the array of the laterals, forming whorls; sample MAK 5663. *Scale bars* 100 μm

and/or higher level taxon are not unanimous. Three characters are usually considered significant in terms of phylogeny and systematics: the outline of the thallus, the array and branching of the laterals, and the migration of the reproductive organs, from the axis toward more distal locations. *Mizzia* has been compared to the Early Paleozoic *Coelosphaeridium* (receptaculitids), the Ordovician *Apidium* Stolley, several other taxa and, last but not the least, the extant *Cymopolia* Lamouroux (Kudo et al. 1997), see below. *Neomizzia* is possibly a junior synonym of *Mizzia* (see "Appendix" below). To a certain extent, *Mizzia* also compares to *Draconisella* Granier and Michaud, *Johnsonia* Korde, *Likanella* Milanović, and *Praturlonella* Barattolo, whose articles consist of single or multiple whorls, arranged on a cylindrical main axis. Comparisons between the latter genera have been attempted by Granier and Michaud (1990). Conversely, in *Mizzia* several simple whorls are present, characteristically arranged on the more or less swollen, barrel-like axis of the articles.

Quoting Kudo et al. (1997, p. 94), "*C. vanbosseae* and *Mizzia* sp. are identical at least in morphology and strongly suggest that *C. vanbosseae* is a living fossil of *Mizzia* sp., which has not varied in genetic constitution throughout its biological evolution for 250 million years." To support this important statement, these authors put forward certain analogies between the morphology and calcification of the extant *Cymopolia vanbosseae* Solms-Laubach, and those of relatively poorly preserved specimens of *Mizzia* sp. from the Middle Permian Akasaka Limestone, in Japan. For the present authors, such a comparison cannot be retained for the following reasons: *Mizzia* and *Cymopolia* are periodically constricted, the thallus forming repetitive elements (articles, segments), but *Cymopolia* is choristoporate, that is from an evolutionary point of view it is more advanced than *Mizzia*, with gametangia and sterile second hand laterals placed in terminal position at primary segments laterals, the latter arising from a more or less cylindrical main axis (stalk). As elaborated below, *Mizzia* is cladosporate, with laterals acting as gametangia, without secondaries, and with a barrel-shaped rather than cylindrical main axis. The calcareous skeleton of *C. vanbosseae*, formed by needle-shaped aragonite crystals, is discontinuous, with an intusannulated proximal surface. It coats only the distal part of the thallus, specifically the gametangia and second-order laterals, excluding the primaries. In *Mizzia*, on the contrary, calcification is usually solid, unless altered, coating the membrane surrounding the main axis.

Mizzia zagarthica sp. nov.

(Figs. 3, 4, 5, 6, 7, 8, 9, 10, 11.)

Origin of the name From the Zagarthian people, ancient name of the inhabitants of the Zagros Mountains.

Holotype and isotypes The holotype is the oblique-transversal section illustrated in Fig. 3, sample MAK 5239, Fahliyan outcrop, Zagros FTB. All illustrated specimens (Fig. 6) originating from the same outcrop (Kuh-e Fahliyan) are isotypes. The material (hand specimens and thin-sections) are housed in the collection of the Exploration Directorate of the National Iranian Oil Company (NIOC).

Type locality Medium- to thick-bedded limestones of the Fahliyan Formation in the Fahliyan anticline, about 19 km northwest of the city of NurAbad (Figs. 1, 2a). The type stratum locates at 5 km west of the Fahliyan village, in the northern part of the Ghari valley (co-ordinates: 51°26′ 35.83″E, 30°11′21.29″N). The co-ordinates are based on the Geodetic system and datum is WGS-84.

Diagnostic characters The aforesaid generic diagnosis is supplemented as follows: Articles sub-spherical or egg-shaped with a large, likewise sub-spherical or egg-shaped

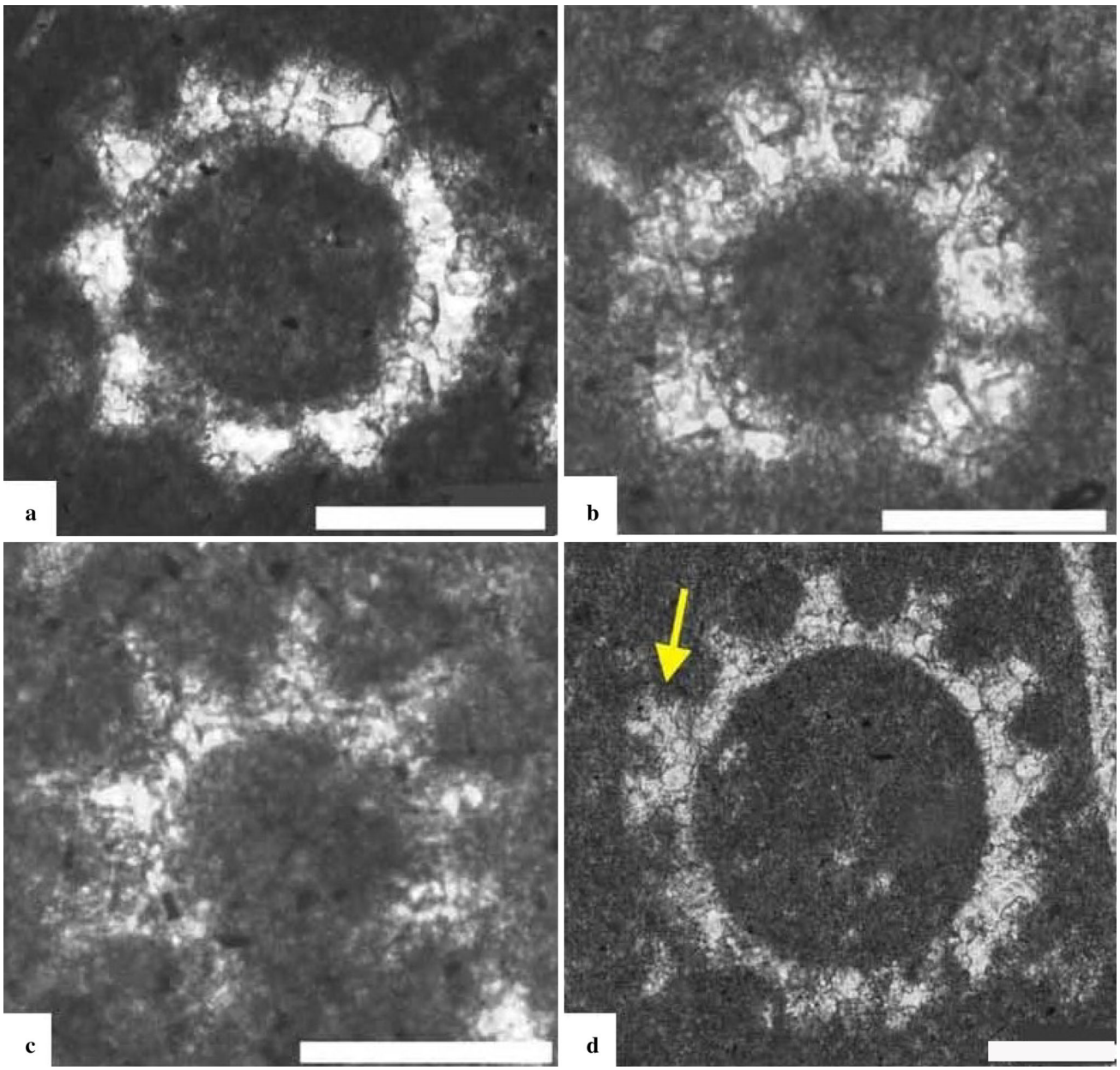

Fig. 6 Transversal and almost transversal sections of *Mizzia zagarthica* sp. nov., Fahliyan outcrop, Zagros FTB. Curved imprints of gametangia (cysts) are present in some of the laterals (*arrow*). **a** Sample MAK 5247. **b–c** Sample MAK 5587. **d** Almost transversal section interpreted in Fig. 4c; sample MAK 5591. *Scale bars* 100 μm

main axis. Only the main, swollen part of each article is calcified, showing approximately six corresponding (fossilized) whorls of laterals. Laterals phloiophorous, first with a narrow proximal lumen, then abruptly widening up, typically triangular in section, non-calcified at tip where forming an irregular, burgeoning and/or coalescing distal cortex. Rounded imprints of cysts, 40–50 μm in diameter, are occasionally present in the skeleton coating the laterals (Figs. 4, 5, 6, 7, 8, 9, 10, 11). Calcite skeleton likely originally aragonitic, solid, smoothly delineating the swollen main axis of the alga.

Description, dimensions and comparisons Based on the compilation of Granier and Grgasović (2000), at least 14 species, dated Permian, were so far assigned to *Mizzia* and the synonymous genus *Eogoniolina*. Detailed comparisons with our new species are beyond the scope of this paper. Solely dimensions of certain species are given in Table 1. In our new species, the *d*/*D* scatter diagram (Fig. 12) shows a high correlation coefficient between variables throughout the studied samples, suggesting that they belong to the same species. In the Barremian *Mizzia dacica* n. comb. only the width (*D*) of the articles and the

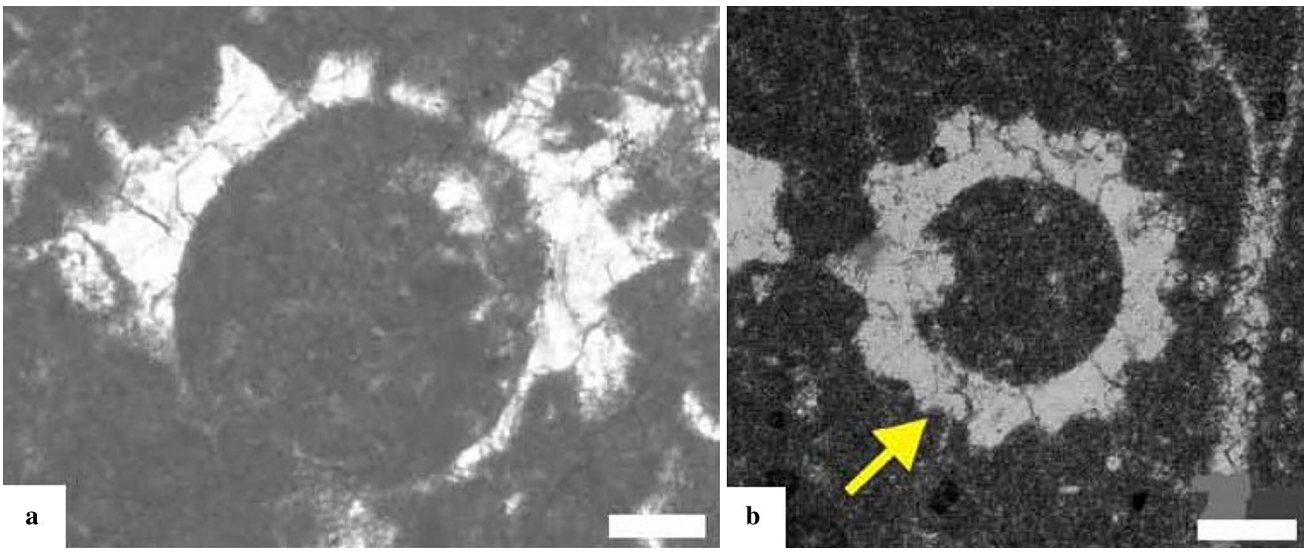

Fig. 7 Oblique-transversal sections of *Mizzia zagarthica* sp. nov., Kalagh outcrop, Zagros FTB. **a** Sample JHT 2066. **b** Curved imprints denoting the presence of gametangia (cysts) in some of the laterals; sample JHT 2074. *Scale bars* 100 μm

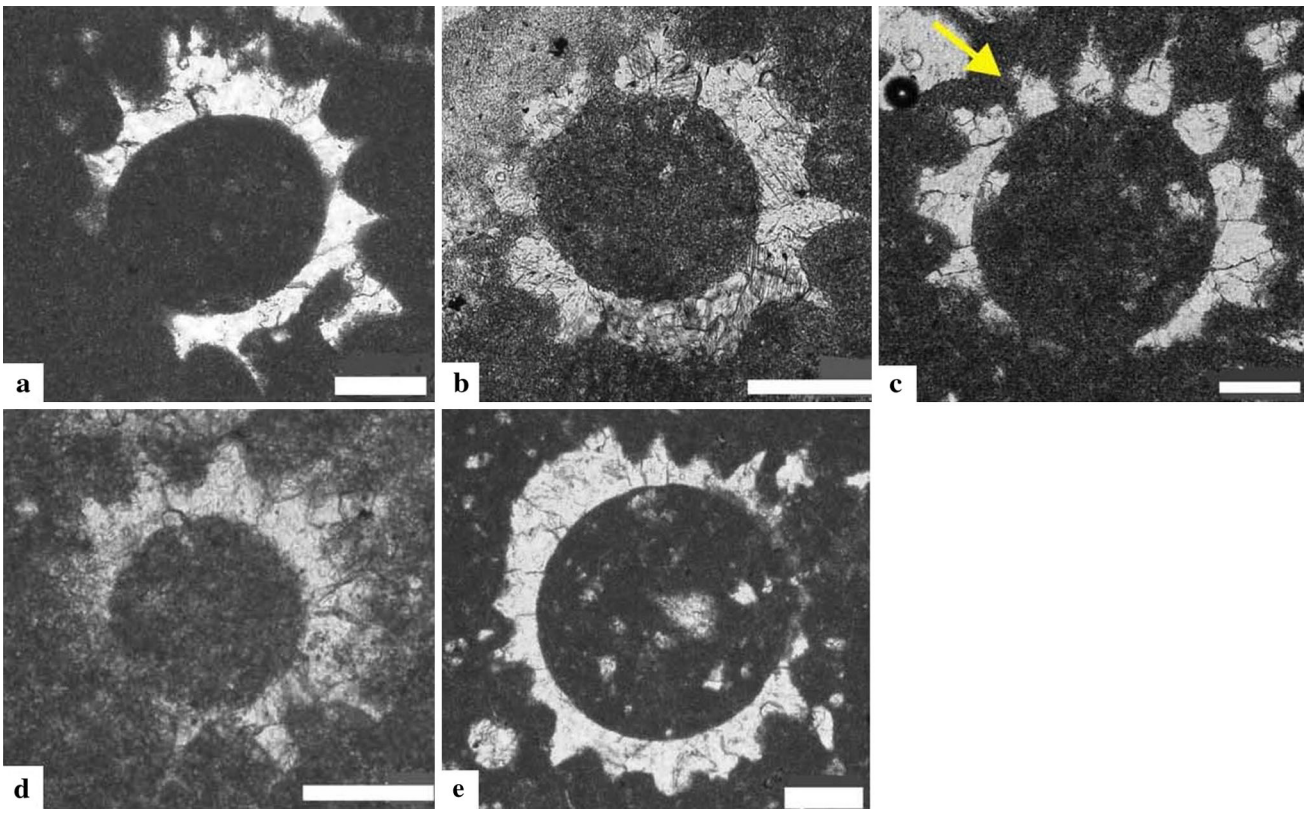

Fig. 8 Oblique-transversal and transversal sections of *Mizzia zagarthica* sp. nov., Kuzeh Kuh outcrop, Zagros FTB. **a**, **b** Sample MAK 4922. In **a**, the lower-left part of the section illustrates the non-calcified, lower, or upper part of the article; note also the irregular, burgeoning cortex in the lower-right part of the section. **c** Curved imprints of cysts are present next to some of the laterals (*arrow*); note the clear-cut proximal lumen of the laterals. Sample MAK 4932. **d** Sample MAK 4938. **e** Sample MAK 4939. *Scale bars* 100 μm

maximum width (*d*) of the main axis overlap with *M. zagarthica* sp. nov., while the *d*/*D* ratio, the spacing (*h*) of the whorls, and the number (*w*) of laterals per whorl are typically lower (Table 1). In addition, in our new species the visible, calcified length of the articles (e.g., Fig. 3) is much less than in *M. dacica*, and some

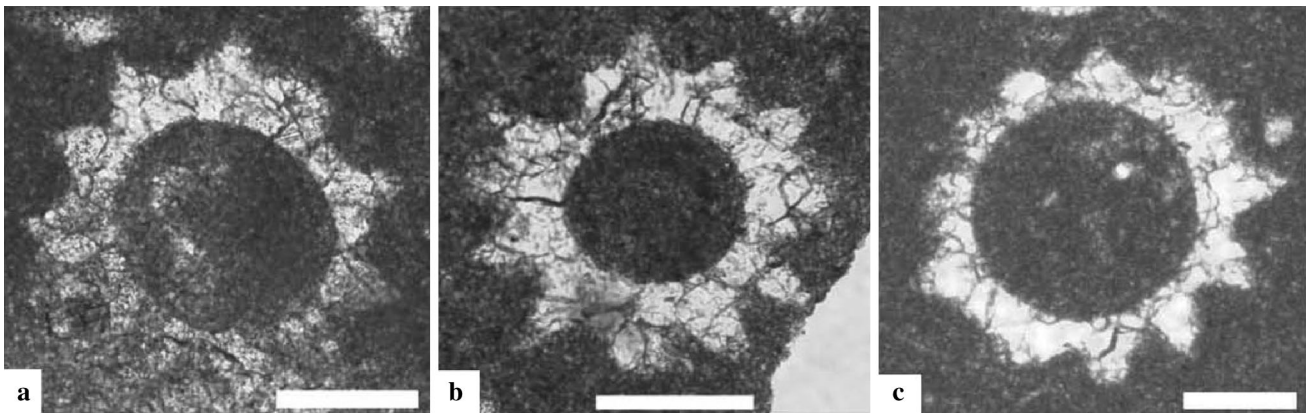

Fig. 9 Transversal and almost transversal sections of *Mizzia zagarthica* sp. nov., Lar outcrop, Zagros FTB. **a**, **b** Sample ARP 897. **c** Sample ARP 902. *Scale bars* 100 μm

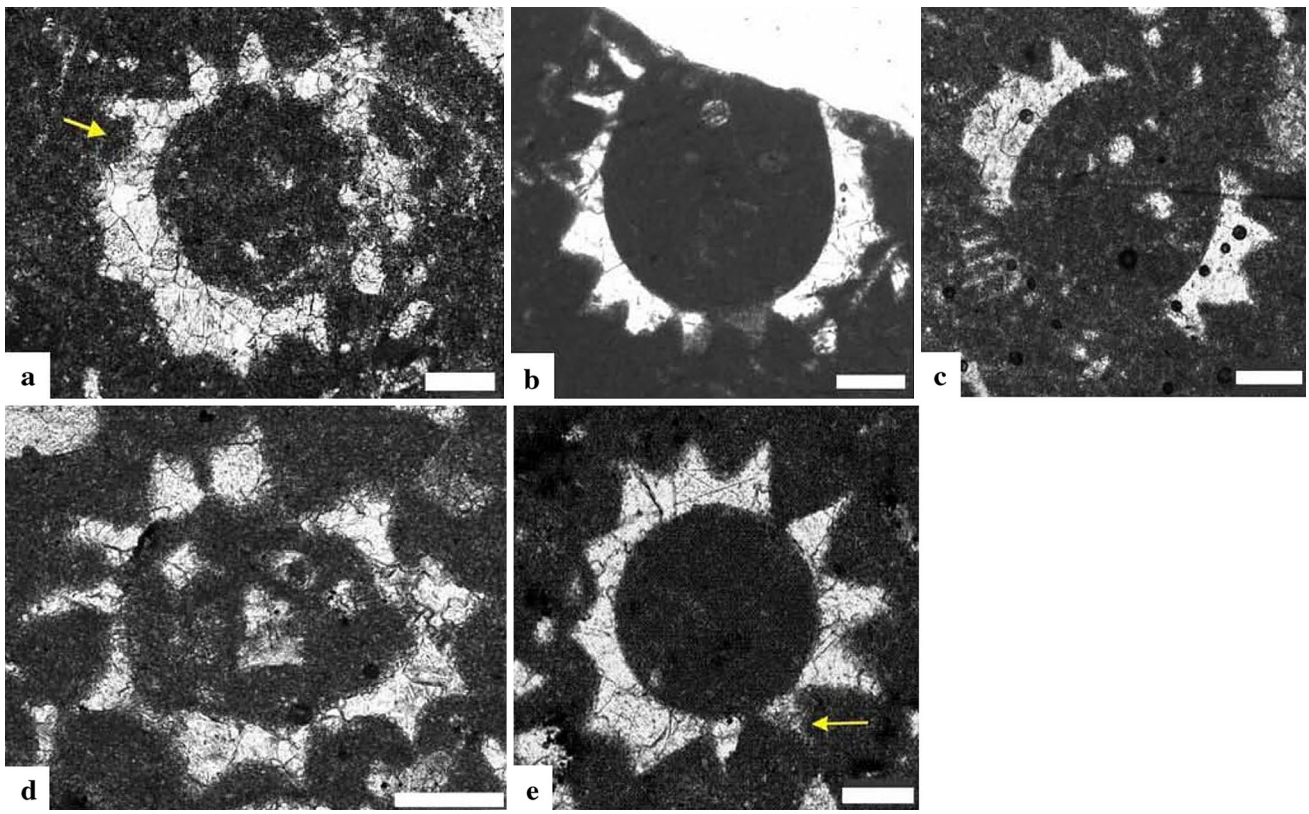

Fig. 10 *Mizzia zagarthica* sp. nov., Surmeh outcrop, Zagros FTB. Rounded imprints of cysts are present in some of the laterals (*arrows*). **a** Almost transversal section; sample JHT 1321. **b** Oblique section; sample JHT 1324. **c** Sub-axial section illustrating a single article (segment) disjointed from the main stem of the alga; sample JHT 1324. **d**, **e** Oblique and almost transversal sections, respectively; sample JHT 1327. *Scale bar* 100 μm

imprints of cysts are visible in the laterals (Figs. 5, 6, 7, 8, 9, 10, 11). Compared to *M. velebitana*, measurements made on our new species (Table 1) overlap, except for the number of laterals per whorl. In *M. velebitana*, the laterals are, however, stockier throughout their length, usually do not show imprints of cysts (which does not means they were missing, see below), and form a quite regular, honeycomb pattern at the tip. The articles of *Mizzia yabei* Karpinsky are far more elongated than in *M. velebitana* and in our Cretaceous new species. *Mizzia minuta* Johnson and Dorr is very close to *M. velebitana*, except for the smaller size and smaller number of laterals in the equatorial region of the articles. *Mizzia cornuta* Kochansky and Herak is characterized by rounded

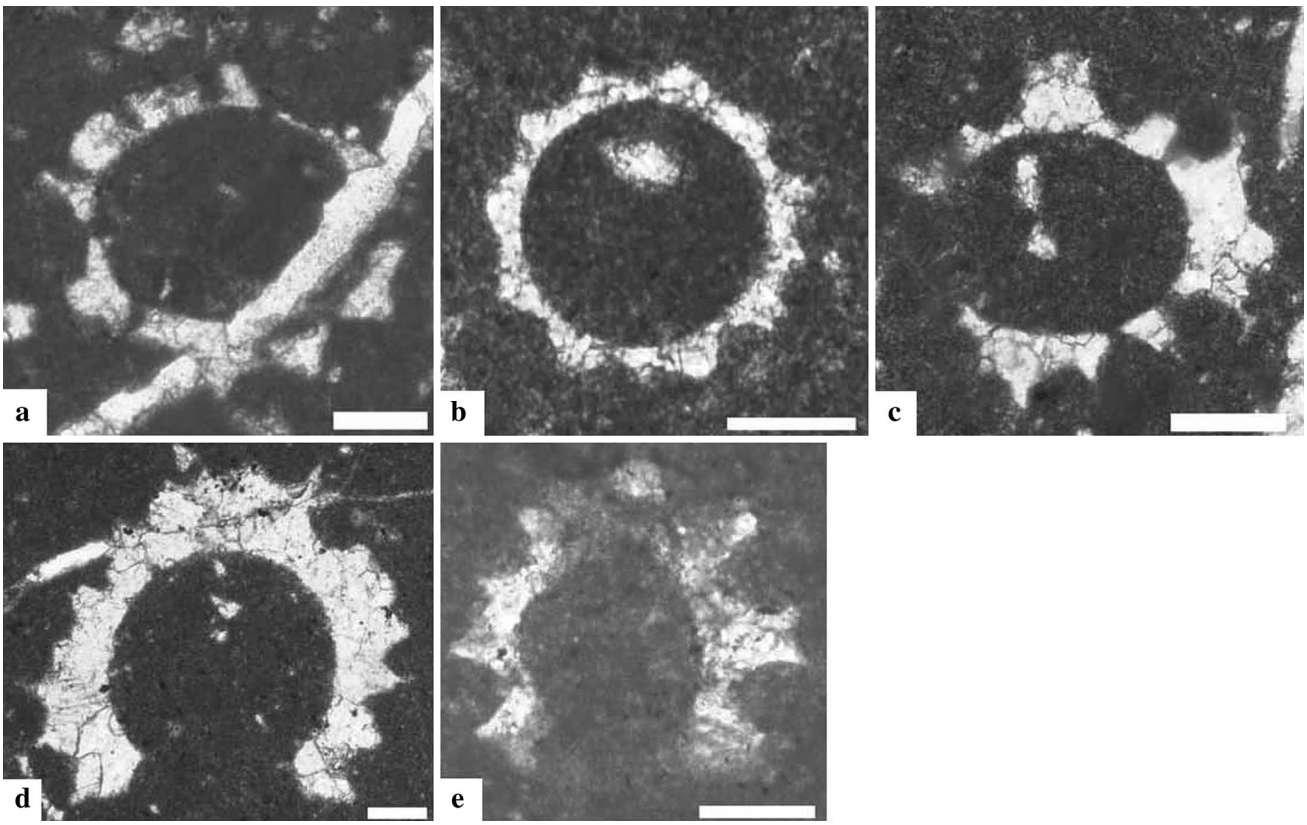

Fig. 11 *Mizzia zagarthica* sp. nov., Anneh outcrop, Zagros FTB. **a**, **b** Oblique and almost transversal sections, respectively; sample ARP 169. **c** The *left* part of this oblique section illustrates the non-calcified, lower or upper part of the article, interpreted in Fig. 4d. Sample ARP 170. **d** The lower part of the section nicely illustrates the non-calcified, lower or upper part of the article; sample ARP 175. **e** Another, similar section; sample ARP 182. *Scale bars* 100 µm

Table 1 Biometric parameters of some species of *Mizzia*, based on literature data

Parameters	*Mizzia zagarthica* sp. nov.	*Mizzia dacica* n. comb., after Bucur (2000)	*Mizzia velebitana*, after Rezak (1959)	*Mizzia yabei*, after Schubert (1907)	*Mizzia minuta*, after Johnson and Dorr (1942)	*Mizzia bramkampi*, after Rezak (1959)
D	0.17–1.00	0.52–0.85	1.17–1.50	0.5–1.00	0.70–1.31	0.70–1.00
d	0.10–0.60	0.27–0.39	0.51–1.20	0.26–0.50	0.26–0.67	0.46–0.60
d/*D*	0.59–0.60	0.46–0.52	0.44–0.80	0.5–0.52	0.37–0.51	0.60–0.66
p	0.02–0.07	0.10–0.15	0.07–0.36	About 0.05–0.30	0.035–0.88	0.09–0.23
h	About 0.06–0.10	About 0.06				
w	Usually 10–15 up to about 20	About 15	20–25	11	13–16	13–15
L	0.20–1.00	0.60–0.71	1.39–1.90	1.8	About 0.5–0.6	About 0.5–0.6

These values, in mm, are evidently dependent of the examined material. In *M. velebitana*, for example, the range of *D* (1.17–1.50 mm) given by Rezak (1959) is much less than in the middle Permian of Greece (Fig. 13, 6.32 mm in specimen 2)

D outer diameter of thallus, *d* inner diameter of thallus, *p* maximum diameter of the laterals, *h* spacing of the whorls, *w* number of laterals per whorl, *L* maximum length of the articles

articles, thick calcareous wall, small dimensions, and oviform laterals, which are closed on the surface. *Mizzia bramkampi* Rezak shows spheroidal articles, with 13–15 funnel-shaped laterals per whorl.

Many specimens from the type locality of *M. velebitana* in Croatia are presumably not perfectly preserved, which may explain the errors of interpretation discussed above. Here, Fig. 13 illustrates particularly well-preserved

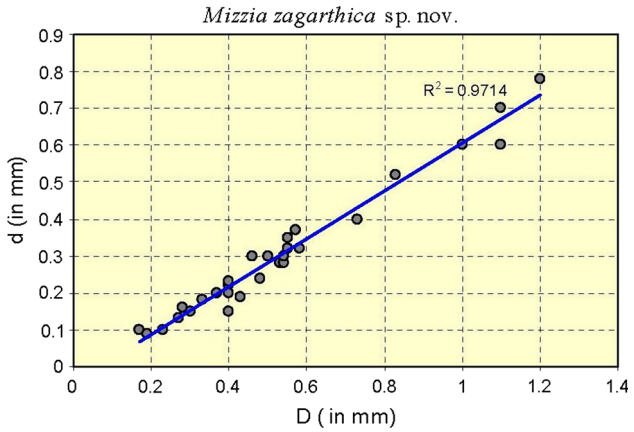

Fig. 12 Correlation between the inner diameter (*d*) and outer diameter (*D*) of *Mizzia zagarthica* sp. nov

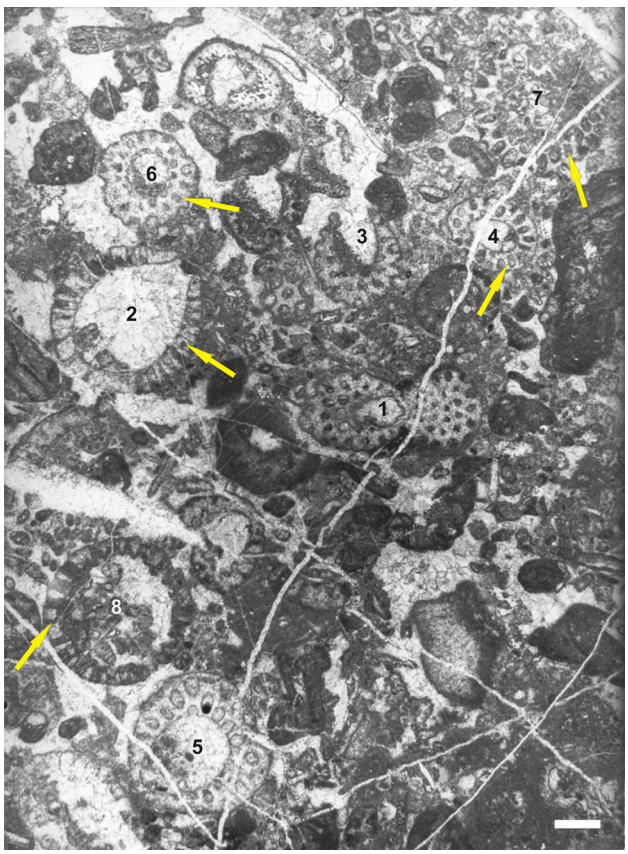

Fig. 13 *Mizzia velebitana* Schubert. Middle Permian of Greece. Prof. Manfred Reichel photo collection, N°7, IGME, Athens. Location: Aghios Mercourios, Attica, Greece. *1* oblique-tangential section cutting two adjacent articles (segments). *2–5* oblique sections of single articles; calcareous skeleton coating the barrel-shaped main axis. *6-8* almost transversal sections; the skeleton is partly removed by bioerosion. *Arrows* rounded imprints denoting the presence of gametangia (cysts) in the laterals. *Scale bar* 2 mm

specimens originating from the Middle Permian of Greece. Some of them have curved imprints located in the calcareous skeleton, hence suggesting the presence of cysts (gametangia) in the laterals. Based on the dimensions of these imprints, when not widened by bioerosion, the cysts were 40–50 µm in diameter, which is the same as in our new species from the Cretaceous. Several specimens of *Mizzia* cf. *velebitana*, originating from the Upper Permian of New Mexico, were investigated (Figs. 14, 15). These specimens do not show imprints of cysts but one of them (Fig. 15) is quite exceptional, illustrating the array of the sauce-shaped whorls of laterals, thereby confirming the views of Rezak (1959).

Dimensions Biometric parameters are shown in Table 1.

Depositional environment In the Zagros FTB, *Mizzia zagarthica* sp. nov. is accompanied by a number of species of *Salpingoporella*, *Clypeina*, *Actinoporella*, *Otternstella*, and *Iranella*. Generally, these dasycladalean algae denote low-energy, shallow subtidal, lagoonal to reefal environments. They occur in wackestones or packstones. Detailed cyclostratigraphic studies reveal that they are found mostly within late highstand systems tracts of the sequences, indicating a shallow-water setting. As our new species is typically found in *Lithocodium-Bacinella* wackestones to packstones, and in bindstones with stromatopores, it points to back-reef or lagoonal depositional environments in inner platform locations. The habitat of *Mizzia* appears to have differed to some extent in the Permian: Quoting Hughes (2005), in Saudi Arabia, "*Mizzia velebitana* […] is not common, and is typically confined to the shallower marine pulses related to early parasequence transgressions within the lower part of the Khuff C reservoir." As reported by a number of authors, *M. velebitana* is commonly found in reefal deposits, associated

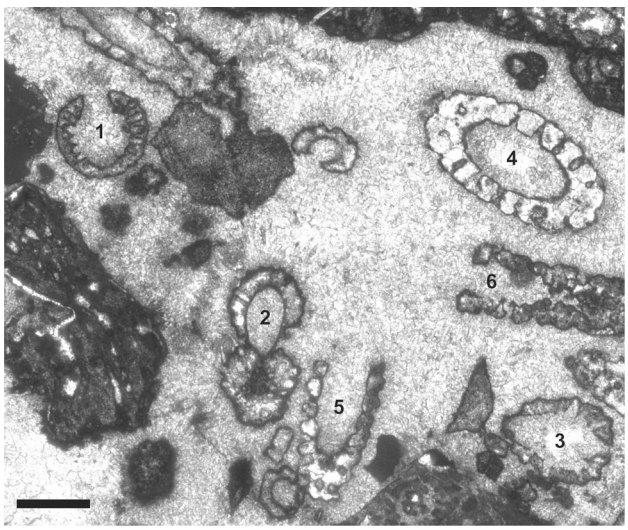

Fig. 14 Dasycladalean algae from the Late Permian of New Mexico, northern Guadeloupe Mountains. Sample AM-329, photograph A. Munnecke. Location: Uppermost Tansill formation, patch reef "7th reef SDR" in Noé (2003). *1–3 Mizzia* cf. *M. velebitana* Schubert; two contiguous articles are cut in specimen 2. *4–6 Oligoporella* ? sp. *Scale bar* 0.5 mm. See also Fig. 13

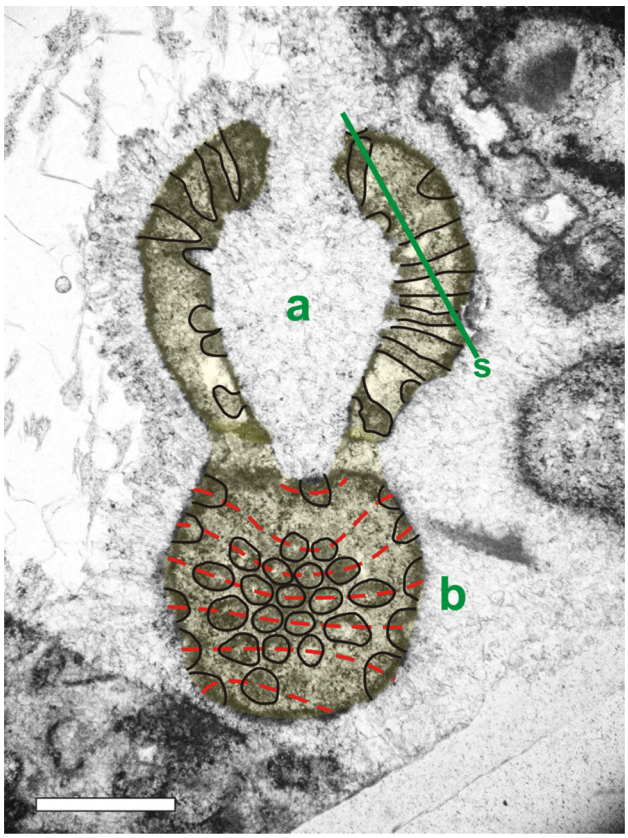

Fig. 15 *Mizzia* cf. *velebitana* Schubert. Location as in Fig. 14, photograph I. I. Bucur. Oblique-tangential section of two contiguous articles, labeled *a* and *b*. *s* trace of an imaginary section alike the section of article *b*. Seven saucer-shaped whorls are visible in article *b*, stacked on either side of the equatorial plane. *Scale bar* 0.5 mm

with *Gymnocodium bellerophontis* (Rothpletz), again denoting a shallow-marine habitat.

Stratigraphic range So far, the genus *Mizzia* was believed to be restricted to the Permian, with its highest development taking place in the late middle or early upper part of the period (Schubert 1907 in Pia 1920; Johnson and Dorr 1942; Rezak 1959; Elliott 1968; Granier and Grgasović 2000; Hughes 2005). New for the record and based on an abundant material from the Zagros FTB, *Mizzia zagarthica* sp. nov. seems exclusively Late Berriasian to Early Valanginian in age, therefore providing a reliable marker. As such it provides a new case of a Lazarus taxon, following a striking return of the genus *Mizzia*, after an apparent long period of rarity possibly resulting from the Permian–Triassic extinction event.

Distribution Besides the Zagros FTB, the species also occurs in the Kopet Dagh, in Berriasian deposits (Bucur et al. 2013).

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Appendix

Notes on *Neomizzia* Lévy and *Banciloporella* Dragastan

The genus *Neomizzia*, type-species *N. elongata* Lévy (1966), was first described by Lévy (1966) from Liassic deposits in Morocco. The free English translation of the original French diagnosis: "Articulated dasyclad (articles with a bead-like arrangement). The simple branches, arranged in whorls are short and widely opened outside. Axial cell with a probable function of sporangium." Although the presence of whorls is not discernible in the illustrated specimens of *N. elongata*, this set of characters meets the emendation of *Mizzia* brought in by Rezak (1959) (see above). Indeed, quoting Lévy (1966), the articulated skeleton and general characteristics and structure of *Neomizzia* are "very similar to the Paleozoic genus *Mizzia* PIA." Summarizing, *Neomizzia* is possibly a junior synonym of *Mizzia* (established by Schubert, not by Pia). An annotated chronology follows.

1966: *Neomizzia elongata* Lévy ex Bucur (2000), the Liassic type-species of the genus, is illustrated, though invalidly typified from a borehole in Morocco. According to Lévy (1966), each article of *N. elongata* contains about 15 whorls of 12–16 branches (laterals), typically triangular in section at the tip.

1978: Neomizzia filipescui is established by Dragastan (1978) from Hauterivian deposits in Romania. No photographs, only drawings, two of them ambiguously including the "holotype", are given in the paper. These drawings are in serious conflict with the protologue, depicting a waxing and waning, annulated outline of the fossil body. At this stage the species is therefore invalid (ICBN, Art. 38.1).

1983: Neomizzia multiramosa is described by Badve and Nayak (1983) from the late Cenomanian to early Turonian Bagh Beds, in India. The species is unambiguously based on the thin section of a single, disjointed specimen, the holotype here reproduced in Fig. 16. It is not a nomen nudum, contrary to Granier and Deloffre (1993). The section shows the typical, triangular pattern of the laterals visible in *Neomizzia elongata*. However, it does not prove the presence of whorls and bead-like shape of an article.

Fig. 16 *Neomizzia multiramosa* Badve and Nayak (1983), the holotype, assumed to illustrate a single article (segment) disjointed from the main stem of the alga. *Scale bar* 200 μm

Fig. 17 Lectotype of *Neomizzia elongata*. Almost longitudinal section showing three successive articles. *Scale bar* 150 μm

Fig. 18 *Mizzia dacica* (Bucur 2000) n. comb. The holotype is illustrating a single article (segment) disjointed from the main stem of the alga. *Scale bar* 100 μm

1989: "Lectotypification" of *N. filipescui* by Dragastan et al. (1989, p. 66), based on the original reference, p. 112, Fig. 2h, actually a drawing, not a specimen. Applying Art. 9.19(b) of the ICBN, the species therefore remains invalid. Separately (Dragastan 1989), a fragment of alga originating from a Tithonian limestone in Romania is assigned to *Neomizzia* cf. *elongata*. Solely based on its shape, the assignment of such a questionable specimen to *Neomizzia* is refuted by the present authors.

2000: Based on the *N. filipescui*, Dragastan (1999, effective 2000) creates the genus *Banciloporella*, whose diagnosis better fits the drawings in Dragastan (1978). Five isolated specimens (pl. 2, Figs. 6, 7, 8, 9, 10) are illustrated, none of them however properly showing the characters described in the diagnosis. Again applying Art. 38.1 of the ICBN the species, hence the corresponding genus are invalid. Meanwhile, *Neomizzia elongata* and consequently the genus *Neomizzia*, are validated by Bucur (1999, effective 2000) based on the designation of a lectotype (Lévy 1966, p. 1, Fig. 2, the longitudinal section showing a string of three articles). This specimen, here reproduced in Fig. 17, actually looks like an articulated *Salpingoporella* or an elongated *Mizzia*. In the same paper Bucur establishes its new *Neomizzia dacica*, from Barremian deposits in Romania. Four nice although disjointed articles are illustrated on which a reconstruction of the alga is proposed. Here, the holotype of *N. dacica* is illustrated in Fig. 18. Transfer to *Mizzia* and comparison with our new species are dealt with above.

In summary, only two valid species, namely *N. elongata* and *N. multiramosa*, are assigned to the genus *Neomizzia* Lévy ex Bucur (2000), which may be a junior synonym of *Mizzia*. *Banciloporella* Dragastan, anyway invalid, remains ill-defined.

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